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TO : See attached list

FROM : CB/Fred Haise

SUBJECT: "To Abort or not to Abort; that is the question!"

Since the precambrian days of Apollo 11 the crew, MCC, and other innocent bystanders passively sit by during sims and watch confirmed PGNS out of plane velocity errors build to the 90 fps limit and abort--it somehow seems UN-American to give up without a fight.

First a little background information on out of plane velocity limits. According to MSC Internal Note No. EG-67-27 titled "Maximum Allowable Lateral Velocity Errors During LM Powered Descent" a 200 fps error at hi gate could be handled by the guidance system though a radar data drop out occurs for 12 seconds after the second update because of the resulting roll angle of nearly 50 degrees. So the reason for a 90 fps limit is not based on a successful landing but rather a successful abort capability assuming the landing radar also fails. Proceeding past the present 90 fps limit with subsequent radar failing to converge the error will result in an unacceptable out of plane error at insertion from an abort.

However, if one accepts the fact that there exists another guidance system (AGS) in the LM plus MCC tracking information for both ascertaining the PGNS error initially as well as a backup abort capability then read on.

To get right to the point--rather than abort on the present limit we should make use of our ΔRLS capability (i.e., N69) in crossrange as we are currently doing in downrange and plan for the LR to work. To exercise this technique three LMS descent were performed with a 0.2 ft/sec.^{2} pipa bias inserted. No other errors were present; that is both PGNS and AGS had perfect state vectors and alignments at PDI. The LR in each case locked on above 40,000 feet but considering velocity error is the problem it doesn't help to have an early lock on. The reason is velocity data is not accepted above 2500 fps and consequently even the Apollo 14 LR case would have converged velocity at about the same point as the super radar on these runs. The following paragraphs describe the three different techniques utilized and the results.

On run #1 the PGNS was allowed to control the vehicle all the way. The pipa problem was observed via a 2° roll angle after throttle up (guidance initiate) and the buildup in DEDA address 211. The PGNS

velocity error was converged at 8 min. 27 secs. and 18,000 feet altitude. Address 211 indicated +00134 (13,400 ft.) and the environment plot indicated the trajectory displaced 13,250 feet. At 8 min. 56 secs. (14,000 ft altitude) a V22N69E, +13400 was entered. This produced a 401 alarm and a very large roll transient settling out at around 60 degrees. At P64 pitchover the roll angle was around 5 degrees but oddly a 45 degree yaw to the right was incurred. The roll angle subsequently built up to 15 degrees in the terminal phase with yaw remaining 45 degrees to the right. The LPD information was good and the vehicle landed at the nominal landing point. The consumables passing through 500 feet altitude were DPS 1875 lbs. and RCS 524 lbs.

Run #2 was also PGNS auto all the way. The distinction was an assumption that FIDO/GUIDO could produce an estimated N69 at velocity convergence. This entry was made at 5 min. into the descent with a V22N69E, +13250E. The velocity error at this point was 43 fps and the max out of plane distance observed was 7200 feet. The initial roll built up to 30 degrees but P64 pitchover was essentially nominal with only 4 degrees roll and yaw. The terminal phase was completely nominal. At 500 feet altitude the DPS quantity was 2128 lbs. and RCS 537 lbs.

On the third run the PGNS mode control switch was placed in attitude hold to allow manual vehicle control. Vehicle yaw was held on the belly band, PGNS pitch FDAI error needle tracked, and roll controlled as required to maintain DEDA address 211 close to zero. The Δ RLS entry (V22N69E, +13250E) was made at 17,000 feet altitude after PGNS velocity error converged. There was no significant attitude transients initially and the P64 pitchover as well as the terminal phase was nominal. The quantities at 500 feet altitude were DPS 2155 lbs and RCS 436 lbs.

In summary all three methods allowed a nominal terminal phase. The first technique is least desirable from the standpoint of distance off the track noted as well as the excess DPS fuel required. Techniques 2 and 3 are essentially the same with the second preferred because of smaller impact on the crew as well as the excess RCS useage incurred with manual control. For all cases the touchdown should be made in attitude hold using out the window or raw radar information for horizontal velocity. Radar dropouts and PGNS subsequent error buildup inhibit use of auto P66.

There seems to be an inconsistency in philosophy whereby we currently abort for the case in point even with a good AGS whereby we continue with PGNS only. It seems the additional failure of LR and AGS in the former or PGNS in the latter leaves one in the same posture for aborts. A new abort limit should possibly be based on either the max velocity error that even the LR cannot converge or the max out of plane ΔRLS the PGNS guidance can handle.

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